# Cooperative Microsystems


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# Report Documentation Page

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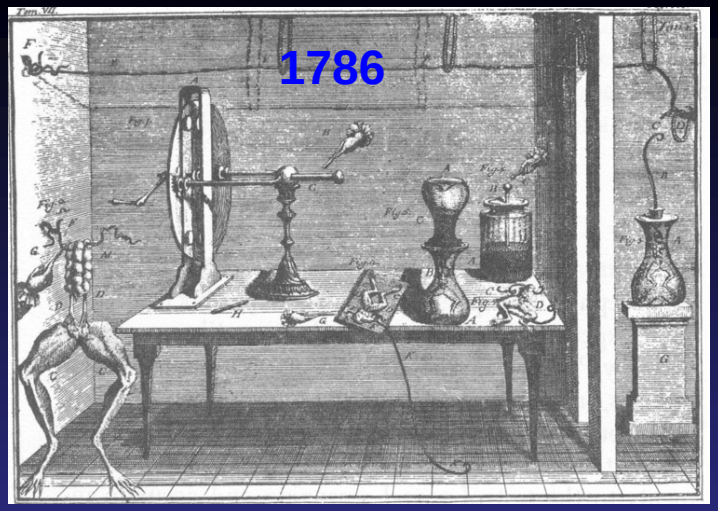
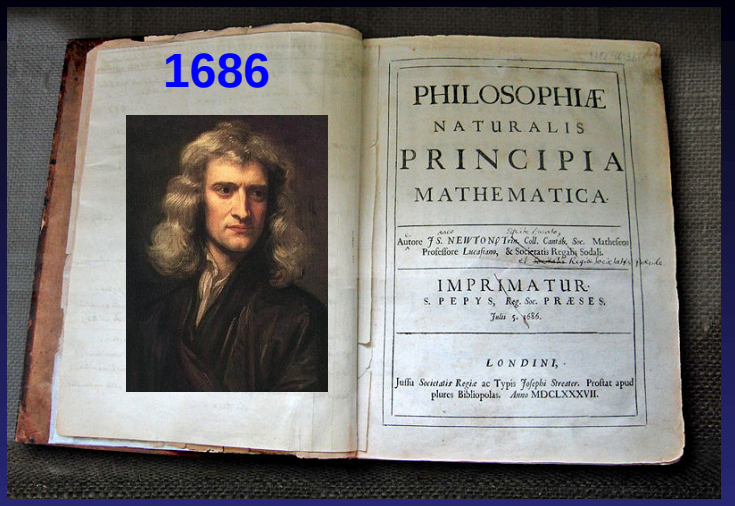
# Cooperative Microsystems and Neural Interfaces



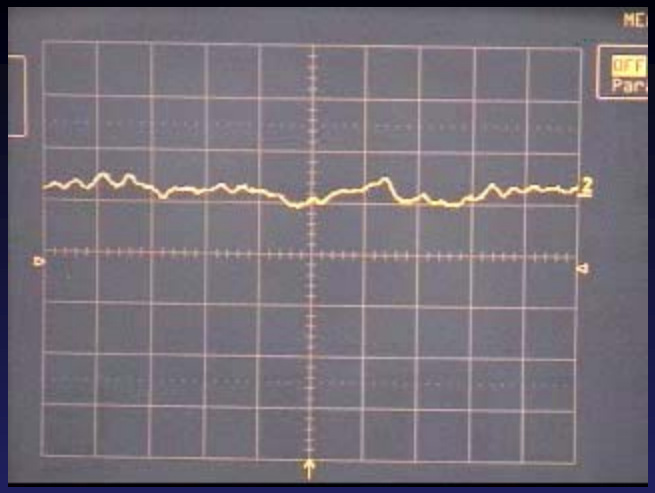

Joseph J. Pancrazio, PhD
Program Director
March 4, 2009

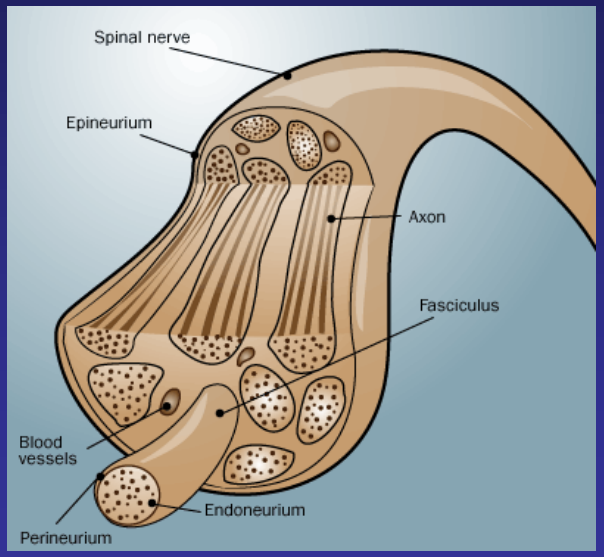
Google “Neural Prosthesis Program”

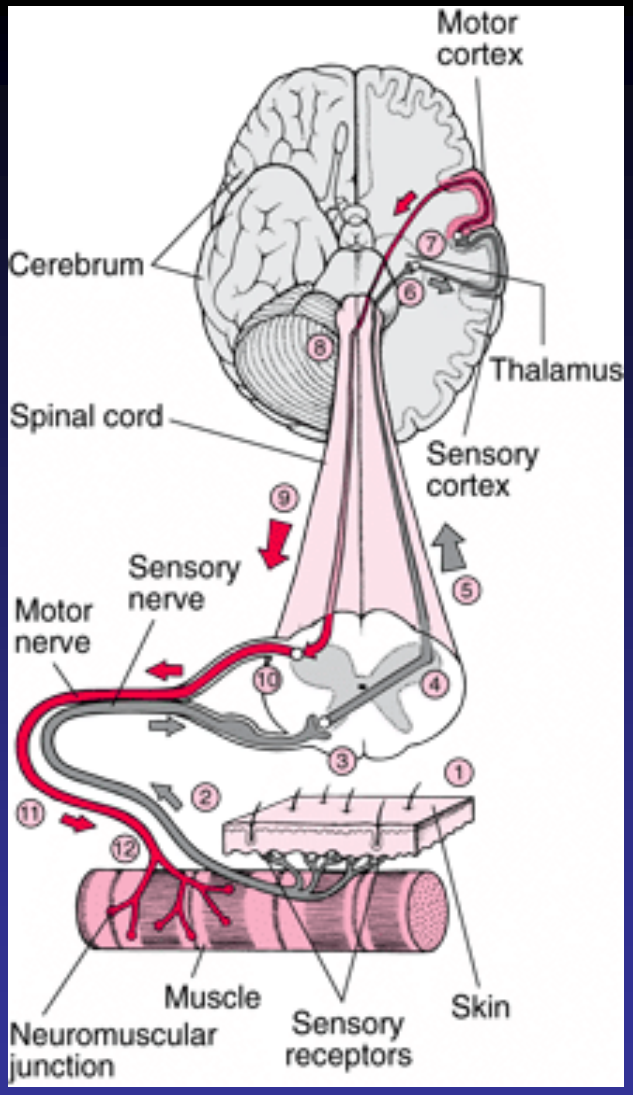
# Outline

- Signaling in the Nervous System
  - Signal sources of cortex and peripheral nerve
- Clinically Useful Neural Interfaces
- Cortical Recording Arrays
- Peripheral Nerve Interfaces
- Challenges and Opportunities for Microsystems in New Neural Interfaces

# Signaling in the Nervous System



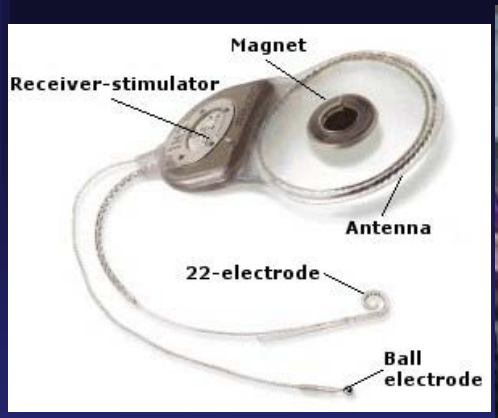



Control signal sources at the level of motor cortex and peripheral nerve

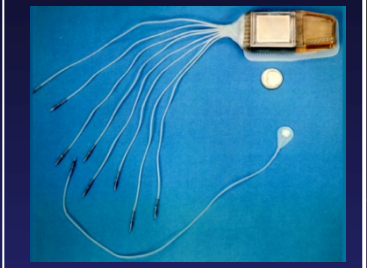
# Clinically-Relevant Neural Interfaces

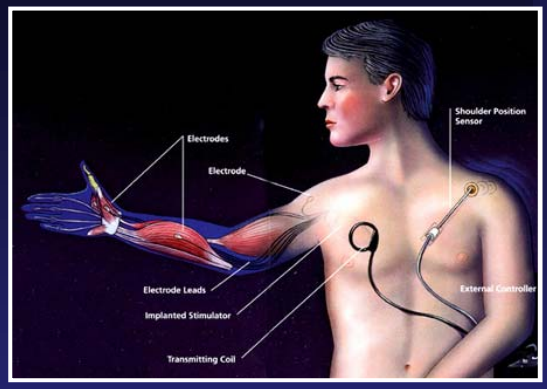
**Neural interfaces have already provided substantial benefits to individuals.**




Cochlear Ltd. Nucleus® 24 cochlear implant system

**Cochlear Prosthesis** bypasses damaged hair cells in the auditory system by direct electrical stimulation of the auditory nerve. 60,000 world-wide



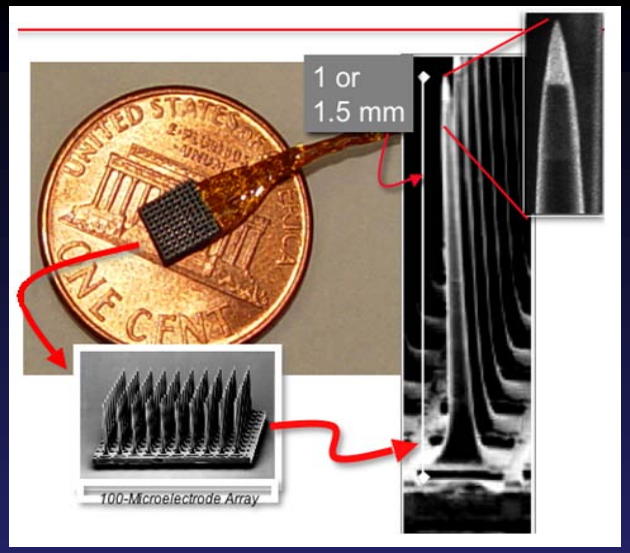



Case Western Reserve University, Cleveland, OH

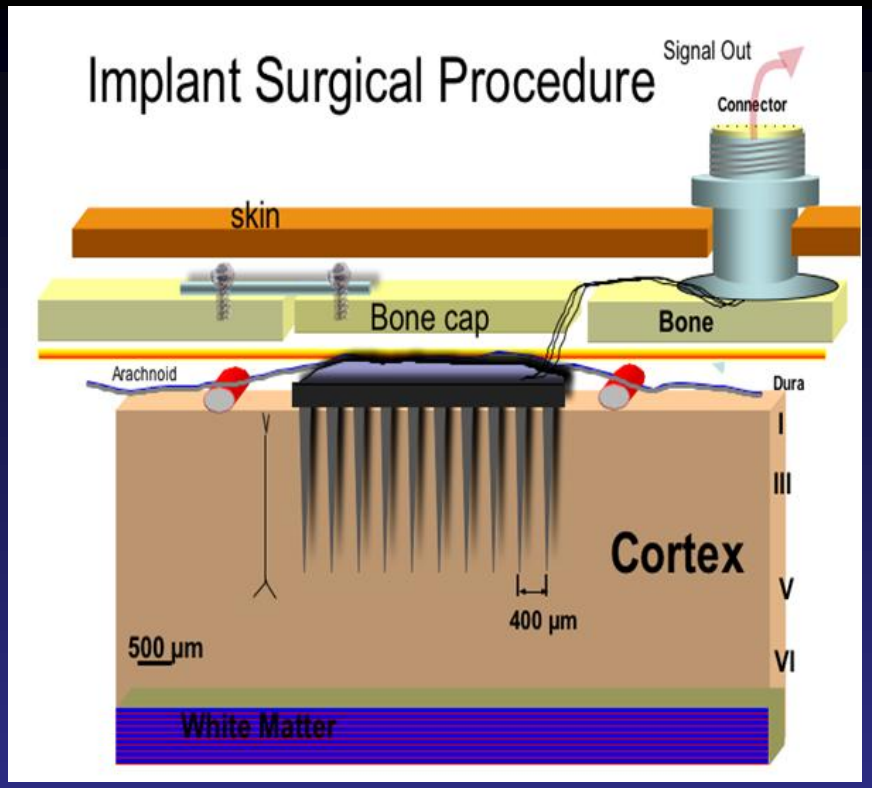
**Functional Electrical Stimulation** has been used to restore motor function in paralyzed individuals. e.g., Upper- and lower-extremity, bladder.

- Neural Interfaces for restoring neurological function via electrical stimulation
- Cortical recording arrays and the peripheral nerve interfaces?

# Cortical Recording Arrays




Design inspired by biology?



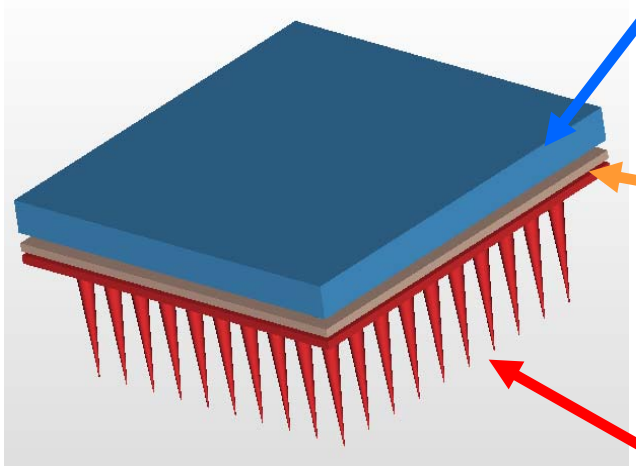

**Critical Issue – tethering forces**

- Pedestal connector, wireless system
- Cable flexibility and scalability

# Cortical Array Microsystems

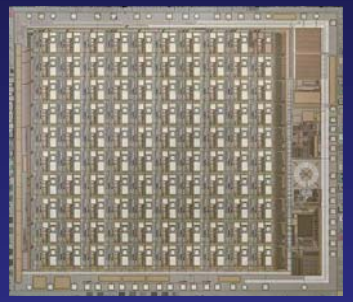
*F. Solzbacher, University of Utah – K. Shenoy, Stanford*

**Performance Specifications**
100 recording sites, integrated spike detection, 6 months capability

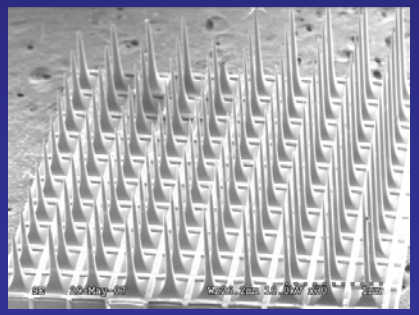


**Thin film fabricated gold-on-polyimide coil for wireless power/data transfer**

**Integrated amplifiers, signal processing & RF telemetry electronics VLSI ASIC**



**Microelectrode array**

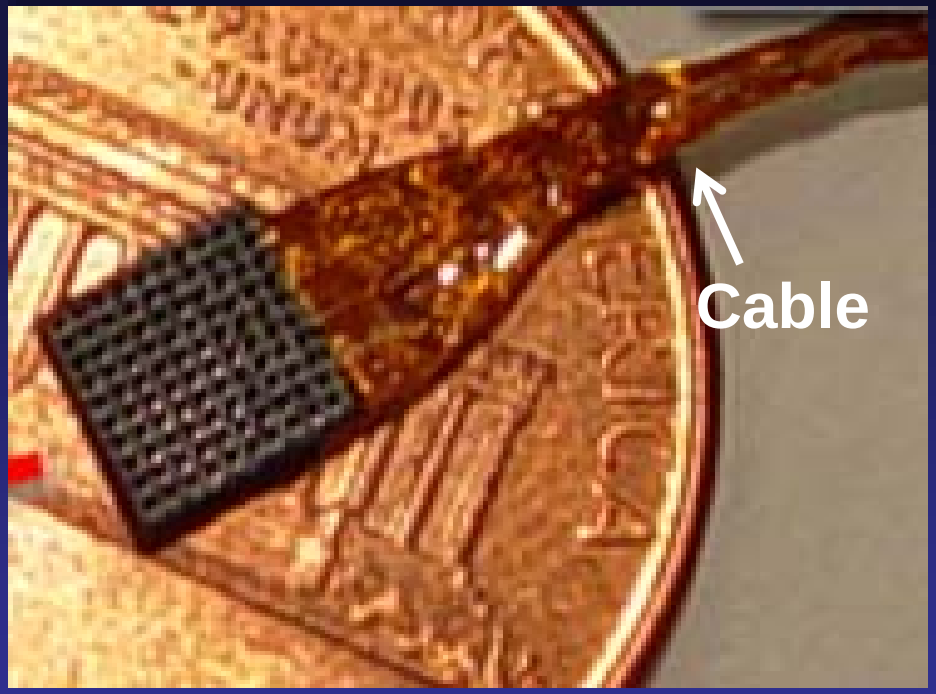


- Demonstrated wireless operation of implanted chip in non-human primates.
- Research platform for freely behaving non-human primates; pre-clinical technology

# Cortical Array Microsystems

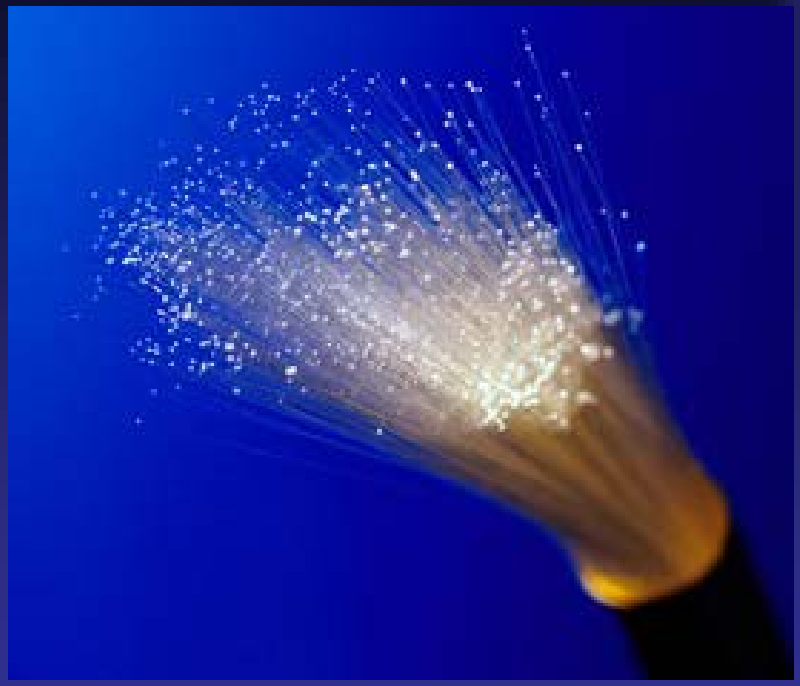
**Critical issue:**

Cable flexibility & scalability – limit to how many leads you can pack.



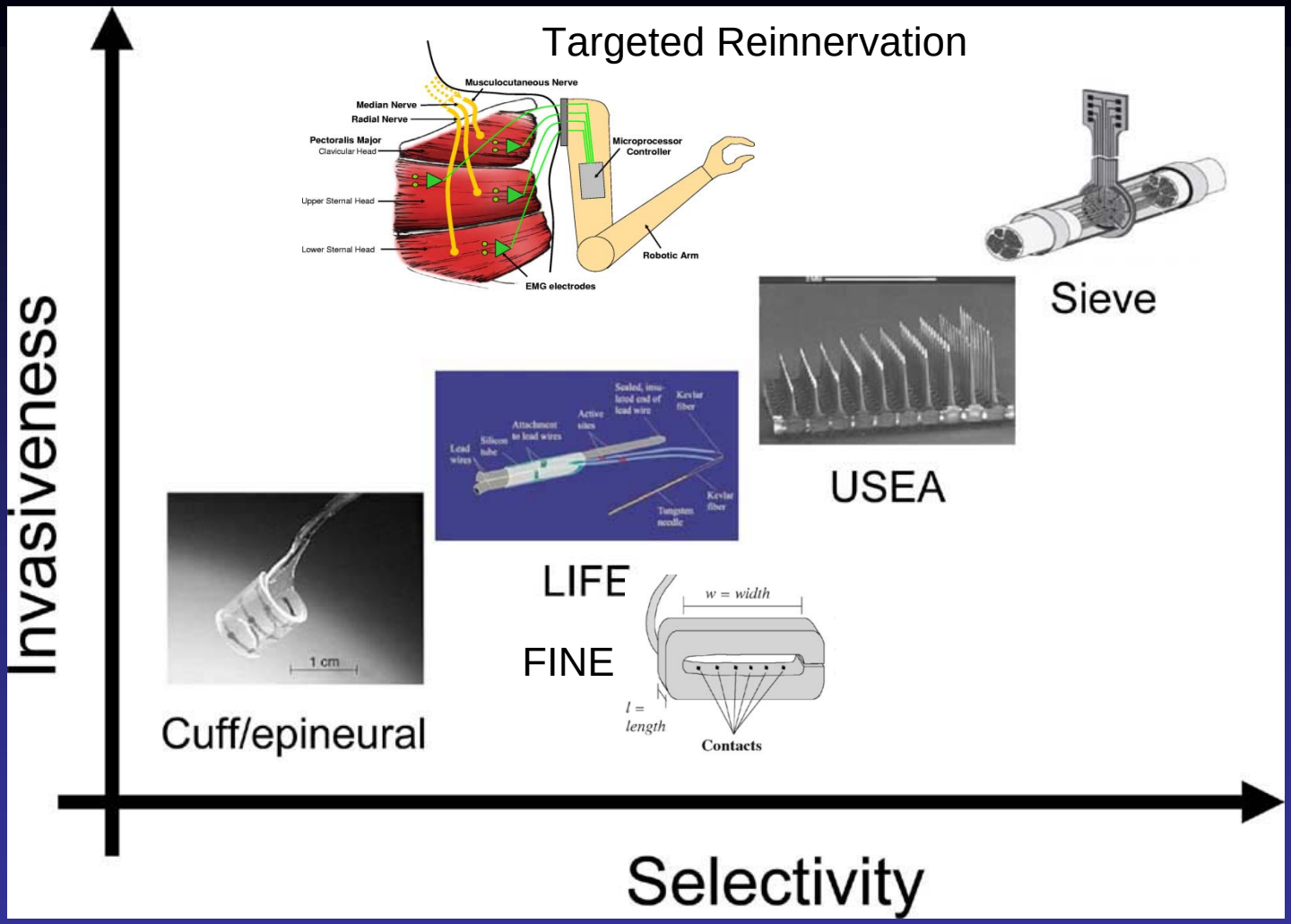

**Possible Approach:**

Collapse cable into a single biocompatible optical fiber.



**Challenge:** develop and demonstrate low power multi-channel data acquisition chip to multiplex data onto one optical fiber

# Peripheral Nerve Interfaces




Adapted from IEEE Trans Neural Syst Rehab Engin 16: 453-472 (2008)

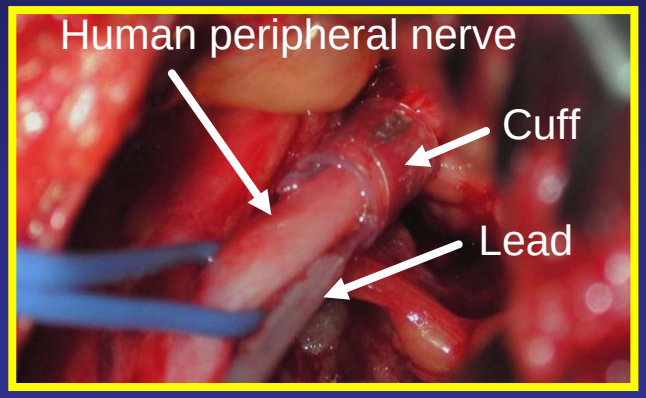
# Peripheral Nerve Microsystems

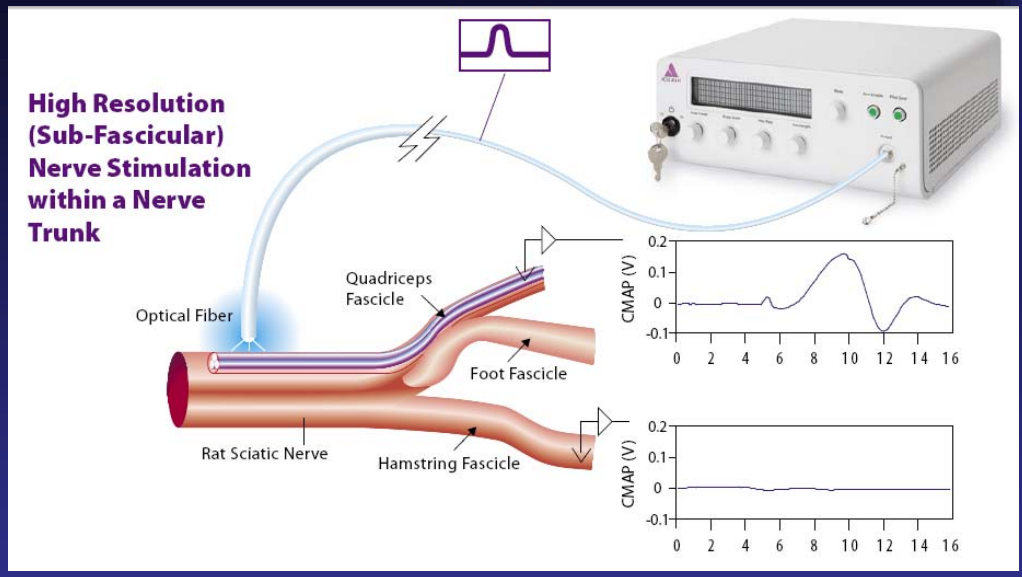
**Critical issue:**

Lack of spatial selectivity with electrical stimulation of cuff electrodes

**Possible Approach:**

Optically-based stimulation – use spatial selectivity of light


Infrared pulses, $\lambda$=4 $\mu$m, <1J/cm$^2$

From *Optics Lett.* 30: 504-506 (2005) – Vanderbilt & Aculight

**Challenge:** implement flexible cuff electrodes that incorporate multiple light sources

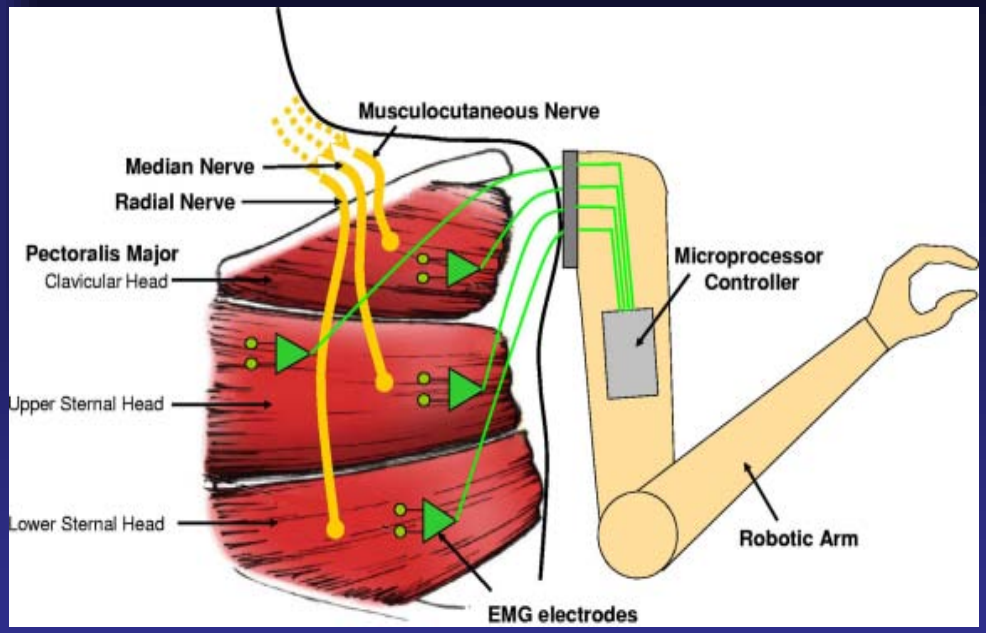
# Peripheral Nerve Microsystems

**Critical issue:**

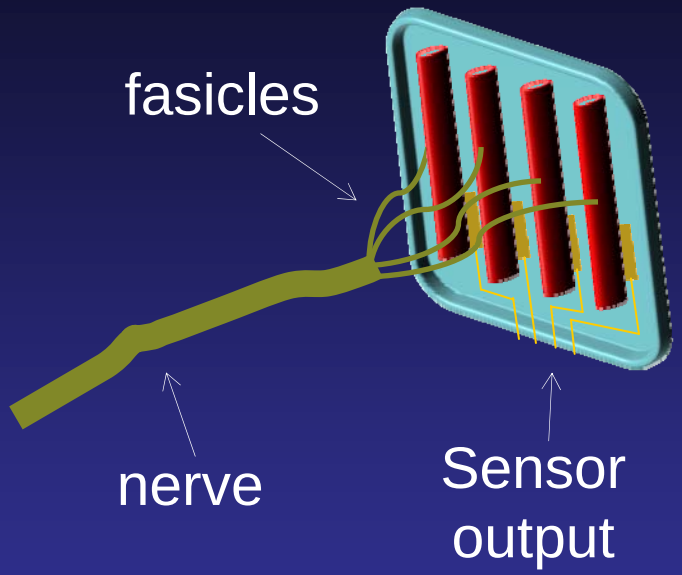
Selectivity of targeted reinnervation limited to donor muscle constraints

**Possible Approach:**

Microscale reinnervation; device integrated muscle fibers




From *J Neurophysiol* .98:2974-2982 (2007)




**Challenge:** develop microelectrode/microactuator integrated 3D structures that maintain myofiber integrity and nerve viability

# Summary

- Neural Interfaces - applications
- Opportunities and challenges for integrating microsystems in neural interfaces:
  - Optical technologies
  - Microscale targeted reinnervation
- Emergence of computational neuroscience systems biology – eventually will result in predictive models of biological that facilitate the design of interactive microsystems.

# Thank you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